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**WPacFIN Island Data Assessment (WIDA) of
Commonwealth of the Northern Mariana Islands
Small Boat Fishery Survey, 1988-93**

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ABSTRACT

The Department of Fish and Wildlife (DFW) in the Commonwealth of the Northern Mariana Islands (CNMI) began in 1979 to monitor the commercial fishery through vendor sales receipts. In 1988 the Western Pacific Fisheries Information Network (WPacFIN) and DFW jointly developed a creel survey program for monitoring the boat-based fishery. The surveys were conducted monthly on 3 randomly selected weekdays (WD) and 2 weekend/holiday days (WE/H). In 1992 the Western Pacific Regional Fisheries Management Council (WPRFMC) and the WPacFIN developed the WPacFIN Island Data Assessment (WIDA) program to evaluate creel survey data and design for the islands of Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands.

The catch and effort data from 1988 to 1993 were evaluated by day types (WD and WE/H), and by quarters for trolling, semiannually for bottomfishing, and annually for spearfishing methods. During the 6 years of the study the fishing effort increased; the mean daily trolling trips showed a 14% increase from 12.8 to 14.6. Mean catch rates were 5.24 kg/gear-h (WD) and 4.07 kg/gear-h (WE/H). Average daily bottomfishing trips increased from 4.2 to 5.3 trips (23%). The number of spearfishing trips averaged 3.4 per day with a mean catch rate of 1.84 kg/gear-h.

Survey sampling guidelines were provided on the number of days required to estimate mean daily effort for each of the three major fishing methods. At the 20% coefficient of variation (CV) precision level the number of survey days for approximating mean daily trolling trips and catch rates was similar. The required survey days for each quarter ranged from 6-10 (WD) and 5-7 (WE/H) for trolling effort and 5-9 and 4-16 for evaluating mean daily catch rates for WD and WE/H, respectively. For determining mean daily bottomfishing effort at the 20% CV within each half of year, 21 and 12 survey days were needed. For estimating daily catch rates, 7 and 25 days were necessary for each respective periods. The number of survey days for estimating annual effort was indeterminate because of the low incidence of spearfishing trips. However, there was a total number of 22 sampling days for an annual mean daily catch rate.

Predictive length-weight regressions were determined for two bottomfish and six pelagic species.

INTRODUCTION

The Magnuson Fishery Conservation and Management Act of 1976 gave the Western Pacific Regional Fishery Management Council (WPRFMC) authority over the fisheries in the U.S. Exclusive Economic Zone (EEZ) in the central and western Pacific Ocean. The EEZ in the Pacific Ocean extends out to 200 nautical miles from shore of the State of Hawaii, the Territories of Guam and American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and possessions of the U.S. There are over 1.5 million square nautical miles under the fishery management of the WPRFMC of which about 8% (~124,000 sq. nmi) of EEZ is around CNMI. In 1981, the Western Pacific Fisheries Information Network (WPacFIN) was created as part of the National Marine Fisheries Service (NMFS) to establish, systematize and maintain fisheries information from this region. NMFS was responsible for providing the best fishery information to the WPRFMC for the development of fishery management plans. These plans were needed to provide a vehicle for promoting recreational and commercial fisheries within the EEZ.

In 1992, the WPacFIN initiated the Island Data Assessment (WIDA) project to evaluate survey designs and data from Guam, American Samoa, and CNMI creel surveys. The WIDA first evaluated the Guam Division of Aquatic and Wildlife Resources offshore creel survey in 1994 and, subsequently, American Samoa small boat and inshore fisheries in 1995. Guidelines for determining the number of sampling days needed to estimate mean daily catch rates and fishing activity at designated precision levels (Kikkawa, 1994; 1996) were produced. In the summer of 1995 WPacFIN/WIDA and the CNMI Department of Fish and Wildlife staff first

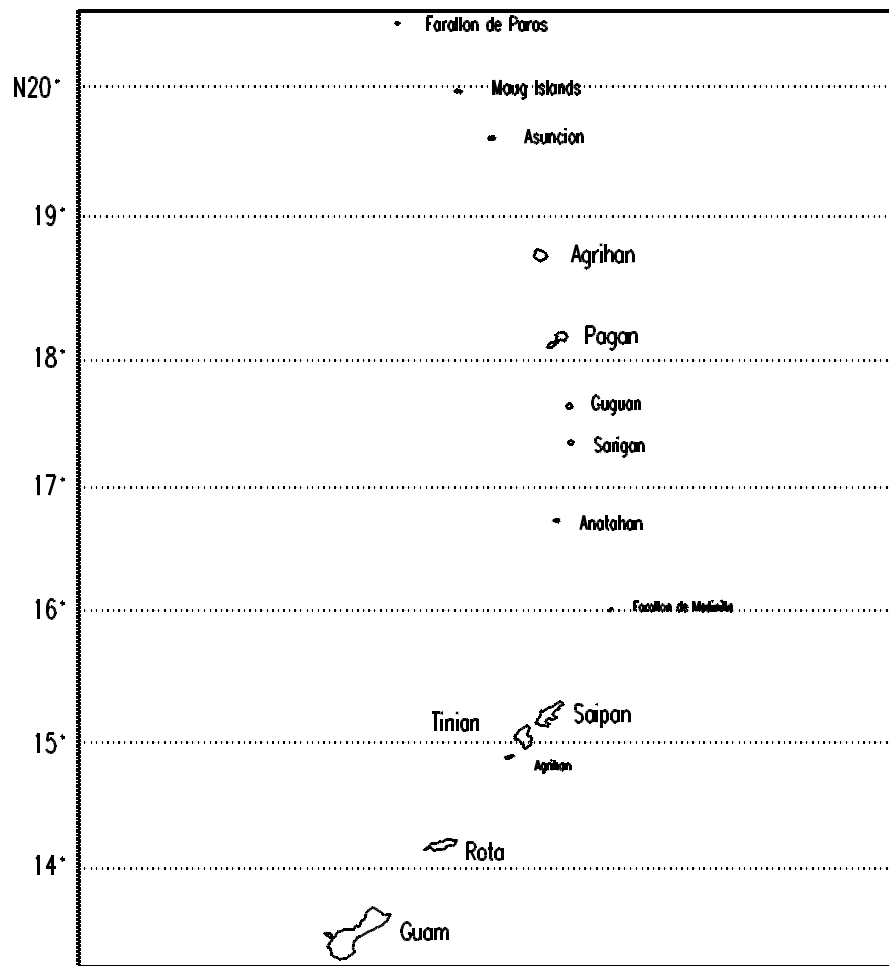


Figure 1.--Map of the Commonwealth of the Northern Mariana Islands and the surrounding offshore banks.

evaluated the current boat-based creel survey and gathered biological information through the survey program. The WIDA study of the offshore fishery included assessment of the fishing activity and catch rates from the three major fishing methods of trolling, bottomfishing, and spearfishing. Biological data were evaluated for stock assessment and management purposes. This manuscript presents the WIDA Project's assessment of the WPacFIN program's fishery data collection system in CNMI during 1988-93.

Study Site

The islands of the Mariana archipelago are located at approximately longitude 145°E and extend between latitude 13° to 21°N (Fig. 1) to form two north-south arcs. The northern group of islands which are of recent volcanic origin stretches from Anatahan to Farallon de Pajaros. These islands have characteristically steep slopes and no fringing reef. The southern islands are predominately larger, raised limestone on much older volcanic platforms that extend from Guam to Farallon de Medinilla. Nearly the entire population of the Northern Mariana Islands (43,345) lives on the islands of Saipan (90%), Tinian (5%), and Rota (5%) (U.S. Census, 1990). Saipan is about 23 km long, 10.6 km wide, and 2.5 km across at its narrowest part. The ridge of high hills extending from the north to central part of the island and a high limestone plateau to the south characterize the island. Also typical for each of the islands of Saipan, Tinian, and Rota, is a high cliff line to the east and lowlands to the west with a well-developed, shallow lagoon with bordering barrier reefs (Fig. 2).



FIGURE 2.--SAIPAN LAGOON ALONG THE WEST SIDE OF THE ISLAND.

Yearly in early January, the Marianas begin to experience a dry period that lasts through most of June. In contrast, late June marks the arrival of the wet monsoons that last through December. Trade winds prevail from October through March and the doldrum conditions for the months of April through September. Consequently, by integrating these two climatic states that four distinct seasons can be defined. During the first quarter (January-March) when conditions are dry with steady northeasterly trade winds, favorable inshore fishing conditions exist in the clear water from low-stream runoffs. However, prevailing trade winds can produce offshore swells, making this a fair season for open ocean fishing. The second quarter or spring season (April-June) is also dry with relatively quiet winds, providing ideal inshore and offshore fishing. During the summer (July-September) winds remain light with increasing chances of rainfall. Although calm conditions exist throughout the season, chances of severe storms with typhoon intensity heighten considerably. The final period from October to December is characterized by the return of the trade winds with accompanying heavy rainfall. It is also a time of severe storm activity. Ambient air temperature on Saipan ranges from 21-32°C. Annual rainfall along the southern end of the archipelago is about 254 cm, decreasing to 178 cm at the northern-most island.

Fishery Monitoring

Since the mid-1970s the DFW has monitored the commercial fishery by summarizing sales ticket receipts from the local fish vendors such as fresh fish markets, roadside fish vendors (Fig. 3), large hotels, and major restaurants. Historically, as Hamm and Kassman reported in 1986, 72% of the fleet was engaged in either part- or full-time commercial fishing with catches accounting for an estimated 80% of total landings on Saipan. However, in August 1988 the DFW and WPacFIN implemented a creel survey program--the CNMI Offshore Expansion System (COES)--to monitor the boat-based (offshore) fishery to provide comprehensive estimates of island-wide catch and effort for all of the major fishing methods (trolling, spearfishing, bottomfishing, longlining, and atulai) from the commercial, recreational and subsistence fishermen. Of all the methods trolling was preferred and practiced throughout the year in Saipan. The summer months made for ideal bottomfishing with calm wind and sea conditions. Spearfishing with both scuba and snorkel was practiced and observed intermittently throughout the year. Netting, longlining, and atulai were highly seasonal or so infrequent that they were not included in this study, although DFW still monitors the catches.



Figure 3.--Typical roadside fish vendor in Saipan. Fish are sold out of the coolers and along with fresh island produce.

From 1990 to 1993 the size of the fishing fleet in Saipan increased by 48%, from 391 to 577 vessels that included an 80% growth of the charter boat fleet from 60 to 108. A typical fishing vessel was a small, outboard-powered runabout (3.66-7.32 m long) that could be readily trailered to any of the launching ramps around the island. Because of Saipan's geological features, most of the launching ramps and ports were situated on the west side of the island. Prevailing northeasterly trade winds caused fishing to occur predominately on the leeward side, just beyond the outer edge of the fringing reef (Fig. 4) and offshore banks to the east and north of Saipan. Besides the charter boats there were a few larger commercial vessels that made occasional extended bottomfishing trips to Farallon de Mendilla, Anatahan, and other northern islands (Fig. 1).

METHOD

The boat-based fishery under the CNMI Offshore Expansion System was monitored through creel surveys that were conducted monthly on 3 randomly selected weekdays (WD) and 2 weekends or holidays (WE/H) between the hours of 0800-1800. Throughout the day the surveyors visited each of the five major launching sites on the island: Sugar Dock, Fishing Base, Smiling Cove, Seaplane Ramp and Charlie Dock (Fig. 5) to assess fishing activity and interview the returning fishermen. Daily fishing effort was assessed by tallying the vacant moorings and empty trailers at each of the launching sites. The returning fishermen were interviewed for necessary catch and effort information (date, type of day, time, boat name, method of fishing, total catch weight, number of fishermen, number of gear, area fished, and species composition) (Fig. 6). Occasionally, when time permitted, length and weight measurements were taken on the catches.

In the evaluation of daily fishing effort by method under the COES, it was necessary to proportionately assign fishing methods to trips that originated outside the survey areas or trips with unidentified methods in order to increase the sample size. Methods were assigned by the ratio of the number of interviewed trips for that method to the total number of interviewed trips within the month. This ratio was expressed algebraically as

$$p_i = \frac{\sum_{j=1}^n e_{ij}}{\sum_{i=1}^m \sum_{j=1}^n e_{ij}} , \quad (1)$$

where e_{ij} is the effort in the number of daily fishing trips on the j^{th} sampling day for the i^{th} method. The proportional allocation factors were determined with respect to the day types and calendar quarters. However, this procedure assumed that (a) the interviews were conducted randomly and (b) the proportion of fishing trips by method from the survey sites was similar to other launching sites around the island.

The amount of catch and effort information gathered through the monthly monitoring schedule of the fishery was inadequate for any reasonable monthly mean and variance estimates for any one fishing method. Thus, it was necessary to pool the effort data by the four climatic seasons and limit the study to the major fishing methods of trolling, bottomfishing, and spearfishing; scuba and snorkel spearfishing were combined into a more general spearfishing method. Because of the paucity of catch rate data for both bottomfishing and spearfishing methods further pooling was necessary such that bottomfishing catch rates were analyzed semiannually and spearfishing annually, irrespective of the day type. The highly seasonal and incidental fishing methods of netting, atulai, and longlining were not included in this study.



Figure 7.--Smiling Cove, one of the five major small boat launching sites on the island of Saipan and berthing for many of the sailing, ferry, and larger commercial charter boats.

Mean daily catch rates were determined with a ratio estimator as the sum of catches over the sum of the efforts and algebraically expressed as

$$r = \frac{\sum_{h=1}^m \left(\sum_{i=1}^{n_h} C_{hi} \right)}{\sum_{h=1}^m \left(\sum_{i=1}^{n_h} f_{hi} \right)} = \frac{C}{f} , \quad (2)$$

where r is the catch rate and C_{hi} is the sum of the catches over the i^{th} interviews and h^{th} survey day in the time period and similarly, f_{hi} is the sum of the effort over the i^{th} interviews on the h^{th} survey day. This estimator was preferred because of the self-weighting properties, unlike the mean of the individual trip catch rates where each observation is equally weighted. However, the variance must be calculated with a special formula (Scheaffer et al., 1990) as

$$V(r) = \left(\frac{N - n}{Nn} \right) \left(\frac{1}{\mu_f^2} \right) \frac{\sum_{i=1}^n (C_{hi} - r f_{hi})^2}{n - 1} , \quad (3)$$

where N is total number of trips in the period, n the number of interviewed trips, and r , the mean catch rate. Since the population mean effort μ_f was not known \bar{f}^2 can be used to approximate μ_f^2 in the equation.

To better understand the trends and the vagaries of the boat-based fishery the distributions of monthly means and variances of catch, effort (fishing activity), and daily interview rates were examined. The temporal distributions of p values and boat registration numbers were reviewed through the median runs test for potential bias in the surveyor's coverage of the fishery.

A secondary objective of the WIDA study involved the evaluation of creel survey data for stock assessment and fishery management purposes. Length and weight information from the more commonly caught species collected during the survey was evaluated and relationships determined through a multiplicative regression model. For the few species that included several years of size frequency distributions the progressive modal analysis was implemented to estimate von Bertalanffy growth constant K and asymptotic length L_{∞} . The data were insufficient for any monthly or seasonal evaluation; thus, size frequencies were pooled over the year and modal components on the distribution systematically identified by fitting a distribution mixture model developed by MacDonald and Pitcher (1979). All of the identifiable modes were assumed to be cohorts and were integrated into a modal progression computer routine.

Estimating Island-Wide Fishing Effort and Catch Rate

Daily island-wide fishing effort and catch rates for the three fishing methods (trolling, bottomfishing, and spearfishing) were estimated by expanding the creel survey data with temporal ($p1$) and spatial ($p2$) adjustment factors. The temporal factor $p1$ elevates the creel survey data by the inverse of the proportion of the day's total island-wide fishing activity occurring within the survey period. Similarly, $p2$ which is the proportion of the island's fishing effort occurring within the survey areas, also expands the survey effort by its inverse. Estimates of the adjustment factors were made by consulting with the fishermen and vendors concerning fishing activities around the island, as well as through some informal observations of the offshore fishery. In the study, monthly averages of the daily p values were used to expand daily fishing effort.

Sample Size Determination

Since the implementation of the COES in 1988 the survey design and the collected data have not been reviewed. One of the major goals of the WIDA study was to provide guidelines for determining the number of survey days needed for estimating mean offshore catch, effort, and daily fishing activity rate at designated precision levels. These guidelines were necessary for effective and efficient creel surveys. Precision of mean catch and effort is often sacrificed with undersampling and, in contrast, oversampling consumes valuable resources. The DFW monitored the offshore fishery on a monthly schedule on 3 WDs and 2 WE/Hs days; however, because of the low levels of daily fishing activities and the infrequent interviews within the month it was necessary to pool the data into calendar quarters or seasons that were determined by the climatic pattern of the Northern Mariana Islands. Generally there were more fishing trips observed on WE/H than WD although not significantly; nevertheless, fishing effort was stratified by day type because of consistent higher rate during the study period. During the process of determining the sample size, reasonable and acceptable estimates of means and variances were

essential for the model since some of the methods required further pooling of the data for better estimates.

Guidelines for determining the number of sampling days needed to estimate mean daily effort and catch rate were developed on the three precision levels of 10, 20 and 30% coefficient of variation (CV). Relative precision or CV of the mean was defined as

$$CV(x) = \frac{SE(x)}{x} \cdot 100, \quad (4)$$

where x is the estimated mean catch or effort and $SE(x)$ is the standard error of the mean (Elliot, 1971; Cochran, 1977) with 10 and 30% as the upper and lower limits to the current survey sampling precision standard of 20%. The sample size n as the number of monitoring days was determined by the following mathematical equation

$$n = \frac{s^2}{CV^2 \bar{x}^2}, \quad (5)$$

where CV is the desired level of precision expressed as a proportion, s^2 is the population variance of the variable to measured, and \bar{x} is the estimated mean (Elliot, 1971; Cochran, 1977). In Eq. (5) the population variance was substituted by an empirically determined function of the mean as described below such that the variance becomes a function of the means. Quarterly means of the prior 3 years were used to estimate the next year's quarterly mean and to consequently predict the number of survey days needed to estimate mean daily participation and catch rates at the 10, 20, and 30% CV levels for each of the methods for the next year. Besides discrete sample size estimates the study presented a dynamic approach of the model in a graphical format. Each graph presented a range of means (effort or catch rate) and number of sample days on the ordinate and correlated with three isopleths of 10, 20, and 30% CV.

The relationships of the means and variances were determined by linearly regressing the log variance on the mean. Catch rates and fishing effort were stratified by fishing methods and day types and pooled into seasons.

RESULTS

During the 6 years of the study, over 95% of the island's fishing activities occurred from the five major launching sites on Saipan. Of the five launching ramps, Sugar Dock was the most active with 46.4% of the island's fishing trips, followed by Fishing Base at 27.6%. Fishing trips from Sugar Dock and Fishing Base averaged 5.2 and 3.1 fishing trips/day, respectively. Charlie Dock was the permanent berth for four charter vessels that averaged 2.1 fishing trips/day. Almost centrally located on the island, Smiling Cove (Fig. 7) harbors most of the island's larger pleasure vessels, sail boats, ferries, and tour boats; however, because of the low level of fishing activity an average of 1.6 fishing boats launched daily from the cove. Seaplane Ramp had the lowest daily average at 0.5 trips.

Fishing activities on WE/H were consistently higher during the 6 years, although the differences in daily activity rates between day types were not significant ($t = 0.553$, $P > 0.583$). The number of fishing trips on WD had increased significantly from 12.03 in 1988 to 16.3 in 1993 ($a_{intercept} = 12.029$, $b_{slope} = 1.9261E-3$, $Pr > 0.04$). While the seasonal number of daily WE/H fishing trips remained relatively constant at 16 trips per day; daily fishing trips were higher in the 2nd and 3rd quarters. Similar to the fishing practices in American Samoa (Kikkawa, 1996), the Saipan trollers would start early in the morning and return to port between the hours of 1700-2000. More recently with the rapid growth of the charter boat fishery, the incidence of interviews on boats with multiple trips during the day increased. Bottomfishermen would typically return to port between 0700-1100 and spearfishermen between 0600-0800 after a night of fishing.

The review of the annual catch and effort frequency distributions indicated the presence of some highliners in the fishery. Despite the higher occurrence of these productive and predominately commercial vessels, the fishery appeared to be monitored objectively. In a median runs test on the temporal distribution of vessel registration numbers of both commercial and recreational vessels it appeared that the interviews were conducted randomly, except in 1988 when some of the commercial fishermen were favored. However, because of the sampling survey schedule most of the fishermen returning within the time frame were trollers and as result the tests were biased toward trolling method.

One of the major obstacles in the analysis of the offshore catch and effort data was inadequate amount of information collected on any one method other than trolling. In order to provide acceptable estimates of means and variances it was necessary to pool the data to increase the sample size for each method. Also, scuba and snorkel spearfishing methods were combined into a general spearfishing method. For both bottomfishing and spearfishing it was necessary to further pool the data across day types. During the period from 1988 to 1993 the mean number of daily trolling trips increased by 14%, from 12.8 to 14.6. Trolling effort on WDs ranged from 0-44 trips per day and averaged 13.2 trips per day. Although the range in the number of trips on WE/H was very similar (0-41 trips per day) average daily effort was slightly higher at 14.1 trips; however, the difference was not significant. A troller typically fished for an average of 5.0 hours with 3.4 lines.

Bottomfishing effort from 1988 to 1993 also showed an increase from 4.2 to 5.2 trips per day, a 23% jump. A bottomfisherman fished for an averaged of 5.5 hours with 3.5 lines. The number of daily spearfishing trips also increased from 3.3 to 3.5 trips per day, or 8%. The number of spears used per trip ranged from 1 to 7 with an average of 3.4. Spearfishing trips lasted an average of 6.0 hours.

For the trolling method, mean quarterly catch rates were not found to be significantly different between day types (WD and WE/H) in a pair-wise comparison, although WD catch rates were consistently higher and ranged from 0.51-78.7 kg/gr-h with an overall mean of 5.24 kg/gr-h. Annual average catch rate on WE/H was 4.07 kg/gr-h with a range of 0.14-20.9 kg/gr-h. Catch rates were highest in 1993 with annual daily means of 8.58 (WD) and 5.75 kg/gr-h

(WE/H). Bottomfishing mean annual catch rates during the first 6 months ranged from 0.21-7.43 kg/gr-r, with an overall average of 2.84 kg/gr-h. Mean catch rate for the second half of the year was lower at 1.84 kg/gr-h and ranged from 0.17-4.12 kg/gr-h. Mean annual spearfishing catch rate was 1.84 kg/g-h with a range of 0.14-6.48 kg/gr-h.

A total of 3,226 individual fishes (eight species) were measured for length and weight, however, only two species were bottomfish (Table 1). Of the sampled fishes, trolling-caught species were predominant with annual landings averaging about 92 tons (51% of the annual commercial landings) (Hamm et. al, 1994). Of the species that were sampled skipjack tuna, *Katsuwonus pelamis*, accounted for over 63% (2042) of all the measurements, followed by mahimahi, *Coryphaena hippurus*, with 638 observations (20%) and yellowfin tuna, *Thunnus albacares* with 389 observations (12%). The length-weight relationships for *Pristipomoides zonatus*, *P. filamentosus*, *C. hippurus*, *Elagatis bipinnulatus*, *Acanthocybium solandri*, *K. pelamis*, *Gymnosarda unicolor*, and *T. albacares* were tabulated in Table 1. Graphically, the fit of empirical data to the model for both bottomfishes were presented in Fig. 8; additionally, length-weight relationships for the pelagic fishes were offered in Fig. 9 and 10.

Length frequency data on the mahimahi ($n = 694$), skipjack tuna ($n = 2,256$) and yellowfin tuna ($n = 396$) were the most comprehensive. The size range of the skipjack tuna extended from 16 to 75 cm standard length (sl) with the highest catches in the 40-60 cm range. Similarly, yellowfin catches were highest in the 40-60 cm range with a size range of 20-124 cm sl. Mahimahi caught around Saipan ranged in size from 56-102 cm sl with the peak catches in the 70-90 cm range. Although the modes in the skipjack size frequency distributions were identifiable, there was no chronologically ordered progression in the displacement of the modes between years. As a result, the modal progression analysis was inconclusive. The data on mahimahi and yellowfin tuna were inadequate for any further analysis.

Sample Size Guidelines--Fishing Activity and Catch Rate Estimates

Sampling guidelines for estimating mean daily fishing activity and catch rate were developed around the historical mean-variance relationships for each fishing method and stratified by type day and quarter. The models that described these relationships were subsequently substituted into Eq. (5), and the means from the last 3 years of daily participation and catch rates were used to approximate the next year's mean catch and activity rates and subsequently the sample sizes. Besides providing discrete sample size estimates, the study presented a graphical model for determining sampling rate. Each graph presented a dynamic approach with a range of mean daily participation or catch rate on the abscissa and the number of sample days on the ordinate. These variables were correlated by the 10, 20, and 30% CV precision isopleths.

The number of survey days for estimating mean daily trolling trips ranged from 6-10 (WD) and 5-7 (WE/H) for each calendar quarter (Table 2 and Figs. 11-14). Information collected on bottomfishing activities was infrequent and required the pooling of the data into 2 semiannual strata and over day types. During the first half of the year, 21 survey days were needed to

estimate mean daily bottomfishing activity and 12 survey days for the second semester at the 20% CV level (Fig. 15). Spearfishing effort remained at very low levels for the last 3 years of the study, such that the days to estimate mean daily activity could not be determined.

Mean quarterly catch rates by trolling fluctuated between 3.7-9.7 kg/gr-h for 1991-93 and as a result, the number of sample surveys days needed to estimate the quarterly means ranged from 5-9 for WDs and 4-16 for WE/Hs (Table 3 and Figs. 16-19). Mean bottomfishing catch rates were lower at 2.1 and 1.2 kg/gr-h for each half of the year, however, because at higher variances 7 and 25 surveys days were necessary to estimate the mean catch rates at the 20% CV (Fig. 20). The number of observations on spearfishing catch rates was greatly reduced so that only annual estimates were possible. For the last 3 years the mean daily spearfishing catch rate was 1.75 kg/gr-h resulting in a predicted 22 sampling days to estimate the next year's mean catch rate (Fig. 21).

DISCUSSION

Since the mid-1970s the DFW has used monthly vendor sales receipts of landings and sales summaries to monitor the commercial fishery. Reported landings were estimated to be over 90% of the total commercial catches (Hamm et. al., 1995). Additionally in 1985, the department began monitoring the boat-based fishery with a creel survey program at the five major launching sites around the island. The survey was designed to provide island-wide catch and effort estimates from both commercial and recreational fishermen by fishing method. From the peak in 1989, commercial landings on the island of Saipan declined by 43% (Hamm et. al., 1995) in spite of a 48% increase in the number of registered vessels; the recreational fleet dramatically increased by 155% and the commercial fleet by 29%. Undoubtedly, the rapid growth in the recreational fishery and the charter boat industry can be attributed to the development of an island tourist industry and a rise in the island economy. Despite of the increase in fleet size annual estimates of total landings from the creel survey have remained at about 140 T and commercial landings through the monitoring of sales receipts have steadily declined from the peak of 227 T in 1989 (Fig. 22). The drop in commercial landings can be partially explained by the declining demand for fish as a result of the growing recreational fleet. During the first 2 years of the study, it was clear that the creel survey underestimated total landings and was, overall, asynchronous with the annual fluctuations of the commercial landings. In this study, it was not very apparent which of the fishery monitoring systems would best track the changes in the fishery. By the design, it is obvious that total landing estimates from the offshore creel survey should be markedly higher than total commercial landings, and differences should increase with the growth of the recreational fleet. Overall, estimates of total island-wide landings were clearly underestimated by both the offshore creel survey and commercial vendor receipts monitoring systems and the survey appeared to be more insensitive to the changes in the fisheries. Although the time series on commercial landings has always been extensive, the system has had a few inherent drawbacks such as (a) omission of the recreational fishery, and, possibly the charter boat industry, (b) inability to monitor some of the direct sales to the hotels and restaurants which have increased in recent years, (c) the often questionable voluntary reporting of commercial sales, accuracy of the landings, and species identification other than the

common pelagic fishes, and (d) no mechanism in the system to validate the reported information.

Daily island-wide fishing trip effort was estimated by expanding the survey data with temporal and spatial expansion factors. The distribution of pI values has remained relatively constant throughout the years and appears to be unresponsive to the daily vagaries of the environmental and fishery conditions. Essentially, the numerical value of the temporal expansion factor pI was dependent on environmental factors, type of day, and fishing method which can all be highly variable between sampling days. In a numerical simulation experiment the variances were compared between a population that was expanded by a constant pI value and a population that would more likely represent the existing fishery conditions with pI values randomly varying between 0.8-1.0. As a result, the variances were overestimated by at least 26% and 24% for WD and WE/H, respectively, when the constant pI was at 0.8. At a higher constant pI value of 0.97, variances were underestimated by 16% for WD and 11% for WE/H. Higher variance errors would most likely occur during the summer months when fishing conditions are ideal and the days are longer. Larger estimate errors of variance would result in the overmonitoring of the fishery.

Historically, catch rates have always been higher on WD than on WE/H, although not significantly. The higher rates can be attributed to the commercial and more experienced fishermen who typically fish on those days in contrast to a larger number of recreational boaters on the WE/H. Fishing activity and the number of registered boats have been steadily increasing since 1988. However, it was necessary to pool the catch and effort data over day types and quarters to increase the number of observations within each stratum because methods other than trolling interception and interviews on returning vessels were declining.

SUMMARY AND RECOMMENDATIONS

During the 6 years of study, fishing activity or effort on Saipan for each of the major fishing methods increased. The creel survey coverage of the fishery by the DFW averaged 40% interview rate on all returning vessels. However, interceptions on bottomfishing and spearfishing boats have proportionately decreased. It is clear that in the later years the survey sampling was conducted disproportionately on trolling vessels. Due to the reduced interview rates on both bottom and spearfishermen, it was necessary to stratify the data by year to obtain reasonable variance estimates and, consequently, acceptable precision levels for the fishing effort and catch rate. The study recommends that the survey team increase the interview coverage of the fishery on methods other than trolling which can be accomplished by concentrating their effort on the times when fishermen would most likely return. Both spearfishermen and bottomfishermen would likely return to port in the early morning hours. Spatially, the most effective approach would be to improve coverage at both Sugar Dock and Fishing Base where 74% of the spearfishing and bottomfishing activity occurs.

Spawning season and age at first maturity for many of the primary management species were undetermined. There are three fundamental ways of estimating age of a fish:
(a) empirically, with tag and recapture method, (b) statistically, by length-frequency analysis, and

c) anatomically, by the ageing of hard body parts. With the limited available resources at DFW, the study suggests using the statistical approach for short-lived species, although collecting enough size-frequency data for any one species for modal or length-weight analysis in a multispecies fishery is often very difficult when catches include a large number of species with few specimens of a single species. This is especially true for bottomfish and reef fishes. A market sampling program can be used to supplement the database for size frequency and maturity, provided samples are collected in an unbiased manner and imported fish are excluded. For the long-lived fishes, ageing of body parts is suggested, although a considerable amount of time and effort is needed for the study. Recent studies have shown that for long-lived fishes, length is not indicative of age (Williams et. al, 1995). For maturity and spawning seasonality studies it would be reasonable to begin with two or three of the most common and commercially valuable species, i.e., snapper or emperors. Seasonality can be determined by monitoring the changes in the gonadosomatic index over time and by observing the relative change in gonadal development to length size at first maturity.

Since 1979, the commercial purchase receipt system has been the mainstay for estimating total commercial landings on Saipan. Albeit, there were a few shortcomings with the self-reporting system that could reduce the accuracy and precision of landing estimates. Basically, the information received from the vendors must be validated; the DFW must be able to demonstrate that the total reported sales can be adjusted accurately to be tantamount to equal total landings. This assumes that all vendors report purchases in a timely manner and that the reporting bias remains constant for the designated time period so that there are no seasonal/holiday reporting biases. Also the misidentification of fish by the vendors will cause some problems for future fishery management. And lastly, with the rapid growth of the charterboat and recreational fleets the commercial vendor receipt monitoring system is becoming less effective in estimating total landings and the more accurate adjustment factor becomes necessary. If the DFW continues with the commercial purchase system for monitoring the fishery, the results of this study encourage the department to develop a program to correct its shortcomings.

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Table 1.--Length-weight regression for fish caught around Saipan during 1988-93. Presented for each species are sample size, (N), standard length (SL), size range of fitted data, goodness of fit ratio (r^2), and estimates of intercept and slope with their respective standard errors (SE) for the model $\log(WT) = a + b \log(SL)$. Weight is in kilogram and standard length in centimeters.

Scientific name	N	SL size range (cm)	r^2 (%)	Intercept (SE)	Slope (SE)
<i>Pristipomoides carbunculus</i>	15	18-37	96	-10.99(0.628)	3.13(0.181)
<i>P. filamentosus</i>	22	25-51	83	-10.92(1.101)	3.03(0.312)
<i>Coryphaena hippurus</i>	694	56-102	89	-9.87(0.155)	2.60(0.036)
<i>Elagatis bipinnulatus</i>	68	28-70	87	-8.50(0.406)	2.25(0.106)
<i>Acanthocybium solandri</i>	52	51-132	52	-7.30(1.208)	2.02(0.262)
<i>Katsuwonus pelamis</i>	280	37-62	91	-11.08(0.224)	3.12(0.058)
<i>Gymnosarda unicolor</i>	19	32-84	96	-8.11(0.439)	2.35(0.111)
<i>Thunnus albacares</i>	390	20-124	72	-5.16(0.203)	1.64(0.051)

Table 2.--Number of days to estimate mean daily offshore participation in Saipan at the 10, 20, and 30% CV levels from 1991-93.

Type day	Method	Qtr	Daily mean	CV Level		
				10%	20%	30%
WD	TRL	1	8.57	29	8	4
WE/H	TRL	1	11.72	21	5	3
WD	TRL	2	10.32	22	6	3
WE/H	TRL	2	14.89	18	5	2
WD	TRL	3	10.40	27	7	3
WE/H	TRL	3	10.89	21	6	3
WD	TRL	4	10.89	38	10	5
WE/H	TRL	4	12.71	24	7	3
-	BTM	1+2	1.69	84	21	10
-	BTM	3+4	3.12	47	12	6

Table 3.--Number of days required to estimate mean daily offshore catch rates in Saipan at the 10, 20, and 30% CV levels for the three major fishing methods: trolling, bottomfishing, and spearfishing. Mean daily catch rate was estimated from the 1991-93 offshore survey interview data.

Type day	Method	Qtr	Mean daily	CV Level		
				10%	20%	30%
WD	TRL	1	4.00	20	5	3
WE/H	TRL	1	4.10	20	5	3
WD	TRL	2	7.11	18	5	2
WE/H	TRL	2	4.50	16	4	2
WD	TRL	3	9.69	25	7	3
WE/H	TRL	3	4.52	23	6	3
WD	TRL	4	3.79	35	9	4
WE/H	TRL	4	4.73	62	16	7
-	BTM	1+2	2.08	37	7	4
-	BTM	3+4	1.24	100	25	12
-	SPR	YR	1.75	85	22	10

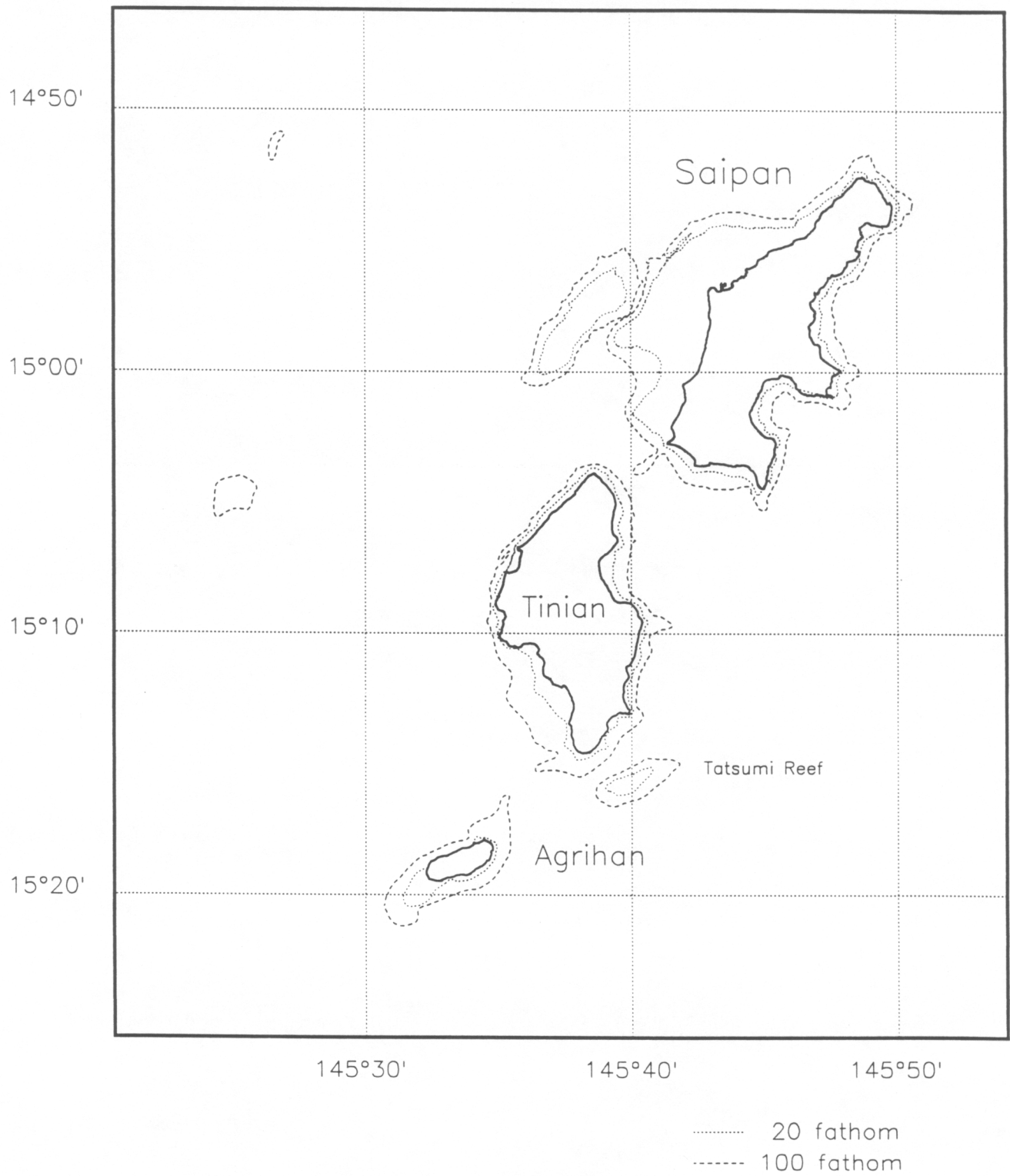


Figure 4.--Map of the islands of Agrihan, Saipan, and Tinian.



Figure 5.--Map of Saipan with study site including the five major launching sites.

INTERVIEW - CNMI BOAT-BASED CREEL CENSUS - INTERVIEW
 DEPARTMENT OF LANDS AND NATURAL RESOURCES: DIVISION OF FISH AND WILDLIFE
 LOWER BASE, SAIPAN. PHONE:322-9627/9628 FAX:322-9629

MONTH/DAY/YEAR: ____/____/____ **TYPE OF DAY**
 INTERVIEWER : _____ WD _____ WE/HO
 INTERVIEW NUMBER : _____ (CODE-1) (CODE-2)

BOAT NUMBER : CM -	NUMBER FISHERMAN :
BOAT RAMP LOCATION :	FISH. METHOD USED :
QUADRANT MOST CATCH : (Numbers 1 thru 8)	NUMBER OF GEAR :
SITE MOST CATCH : (Numbers 9 thru 24)	BAIT USED :
WAS A FAD FISHED ? YES NO	ETHNIC GROUP :
WHICH ONE(S) :	WEATHER: :
LAUNCH TIME :	CLOUD COVER :
LANDING TIME :	SURF SIZE :
ACTUAL FISH TIME :	% CATCH KEPT :
	% CATCH SOLD :

SUMMARY DATA	ACTUAL	CALC.	ESTIMATED	OTHER INFO. / REMARKS
TOTAL NUMBER FISH				
TOTAL WEIGHT (KG)				
TOTAL NO. SPECIES				

SPECIES: _____ NUMBER FISH: _____ WEIGHT FISH: _____			SPECIES: _____ NUMBER FISH: _____ WEIGHT FISH: _____			SPECIES: _____ NUMBER FISH: _____ WEIGHT FISH: _____			SPECIES: _____ NUMBER FISH: _____ WEIGHT FISH: _____		
* * *	FORK LENGTH (MM)	FISH WEIGHT (KGS)	FORK LENGTH (MM)	FISH WEIGHT (KGS)	FORK LENGTH (MM)	FISH WEIGHT (KGS)	FORK LENGTH (MM)	FISH WEIGHT (KGS)	FORK LENGTH (MM)	FISH WEIGHT (KGS)	
1											
2											
3											
4											
5											
6											
7											
8											
9											
1 0											

NOTE: -Record species name, not species code. Species code will be filled in before entering data.
 -Measure and weigh as many fish as possible. Use the next column when more than 10 fish per species are present.

Figure 6.--CNMI boat-based creel survey interview form.

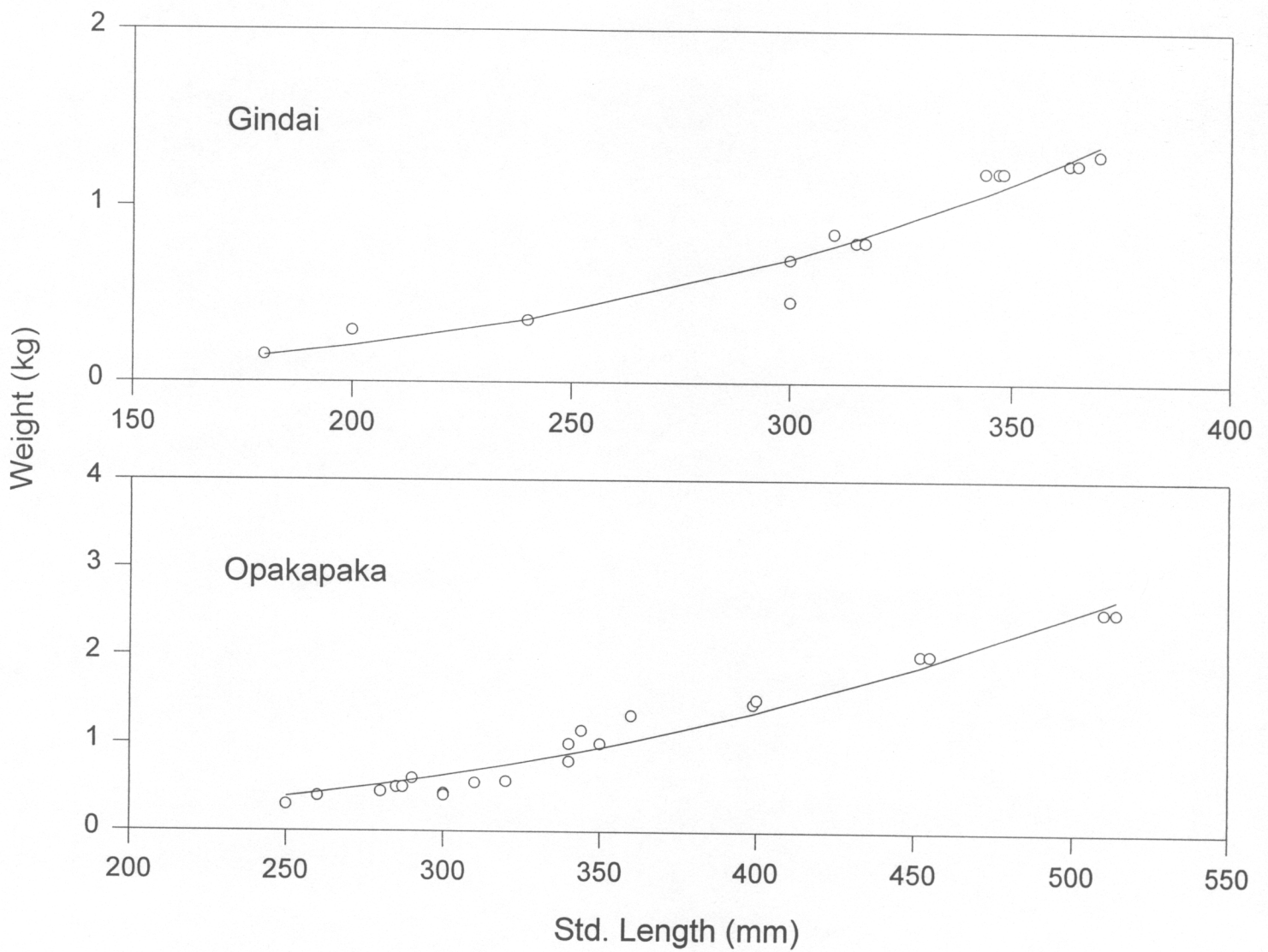


Figure 8.--Length-weight relationships of the two prominent bottomfish species, the gindai (*Pristipomoides zonatus*) and the opakapaka (*P. filamentosus*) caught around the island of Saipan from 1988-93.

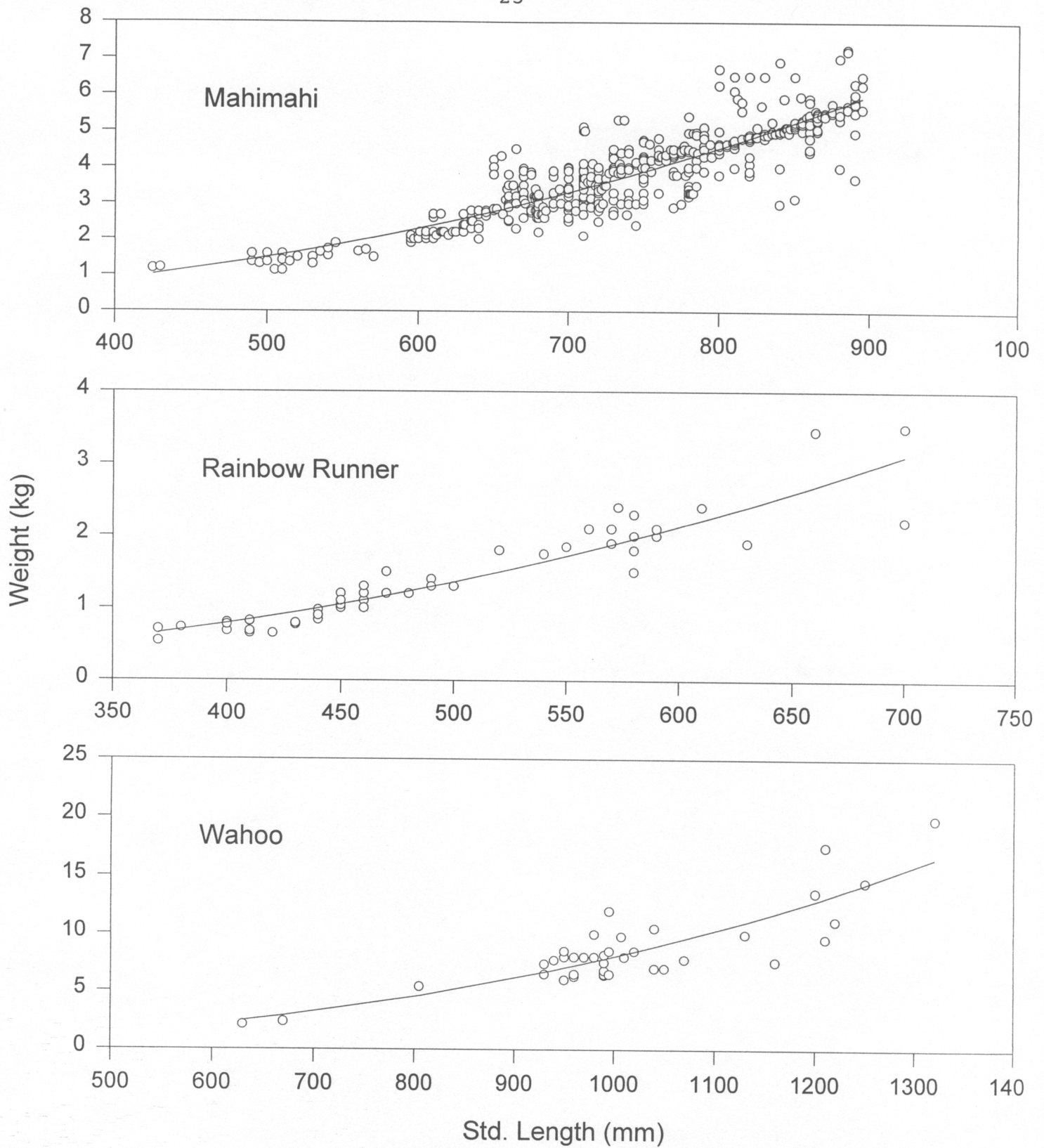


Figure 9.--Length-weight relationships of three pelagic species, mahimahi (*Coryphaena hippurus*), rainbow runner (*Elagatis bipinnulatus*), and wahoo (*Acanthocybium solandri*) caught around the island of Saipan from 1988-93.

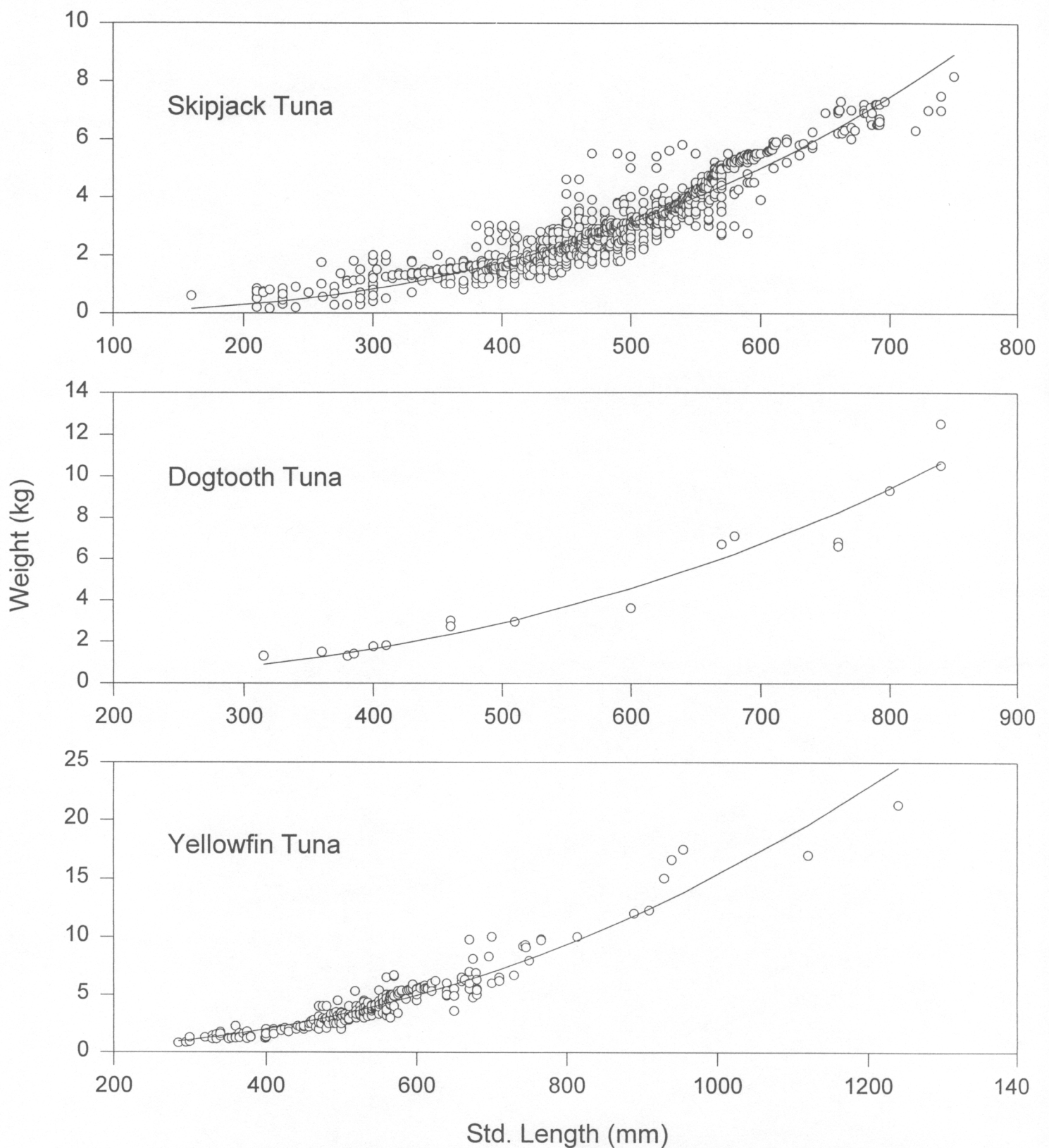


Figure 10.--Length-weight relationships of three tuna species, skipjack (*Katsuwonus pelamis*), dogtooth (*Gymnosarda unicolor*), and yellowfin (*Thunnus albacares*) caught around the island of Saipan from 1988-93.

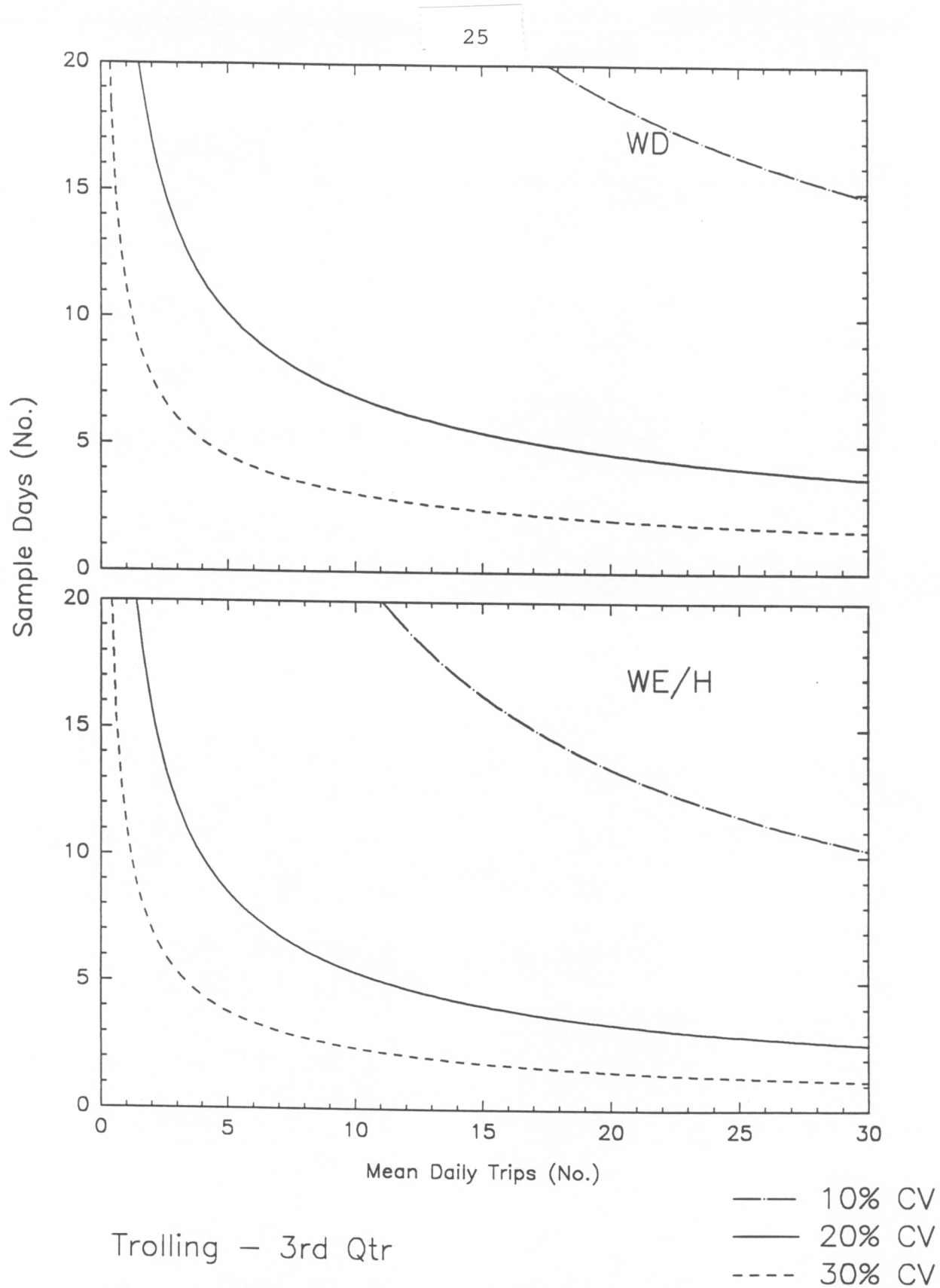


Figure 11.--Required sample size during the third quarter for estimating mean daily trolling activity around Saipan at the 10, 20, and 30% CV levels for both WD and WE/H.

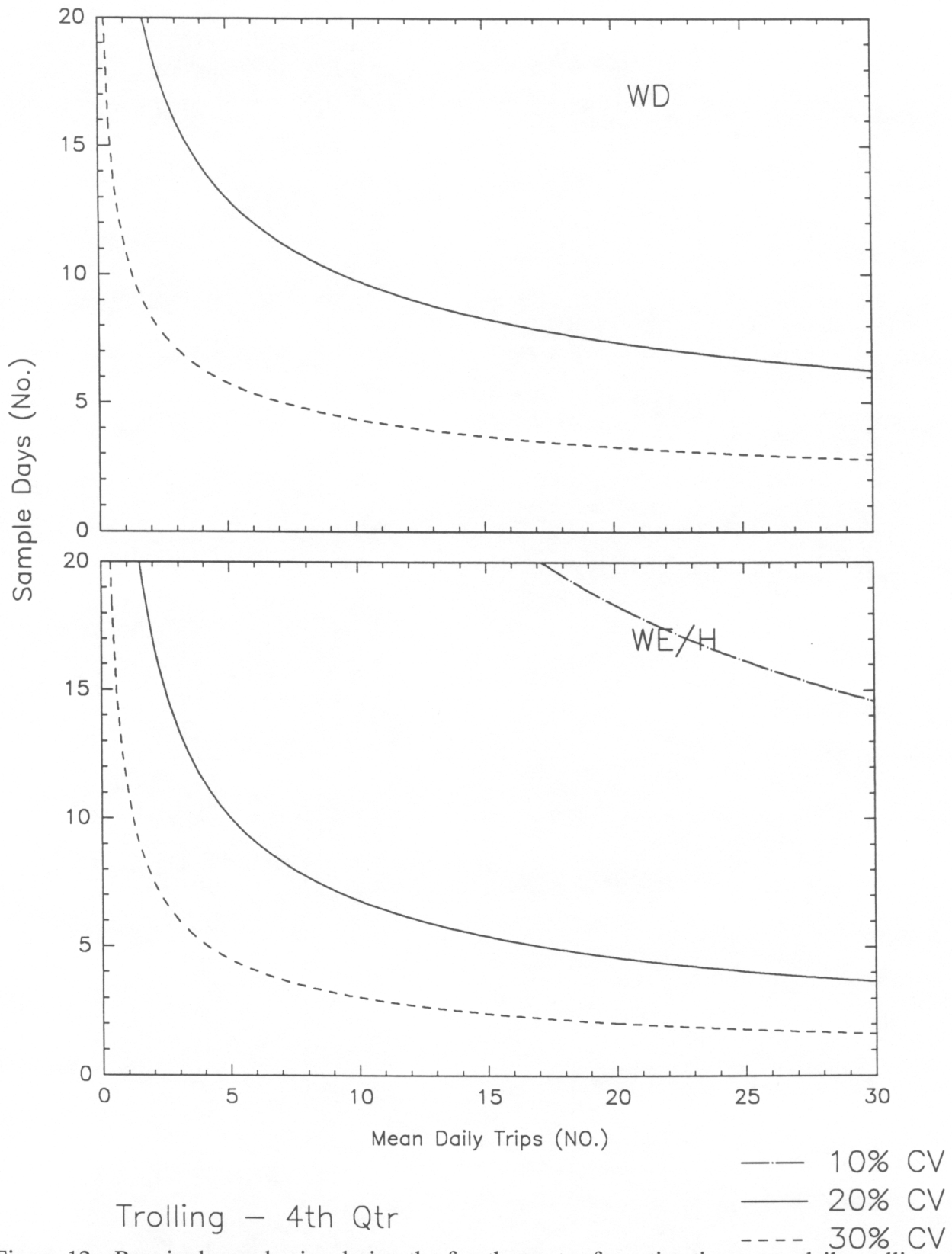


Figure 12.--Required sample size during the fourth quarter for estimating mean daily trolling activity around Saipan at the 10, 20, and 30% CV levels for both WD and WE/H.

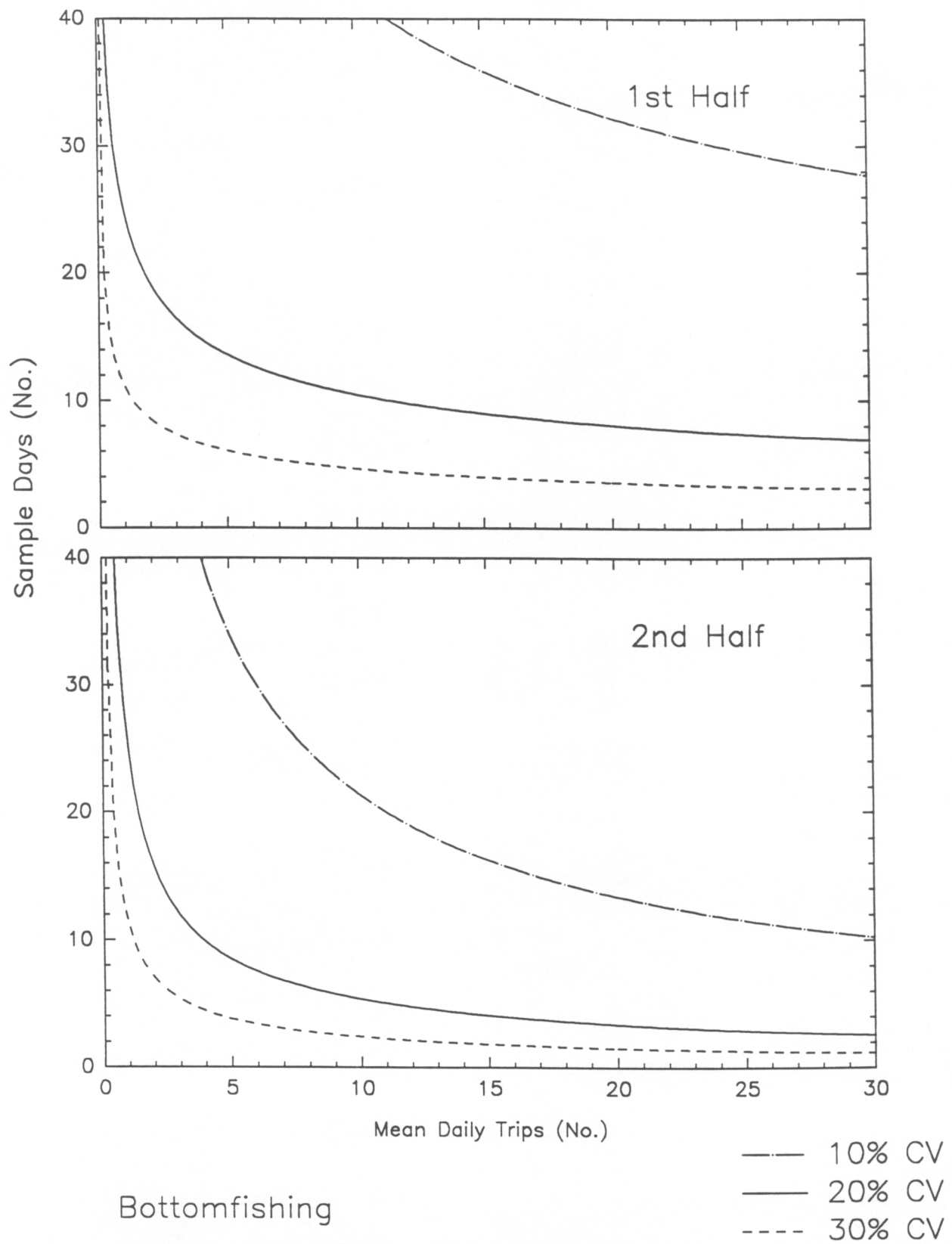


Figure 13.--Required sample size for estimating bottomfishing activity at the 10, 20, and 30% CV levels each half of the year with WD and WE/H day types combined.

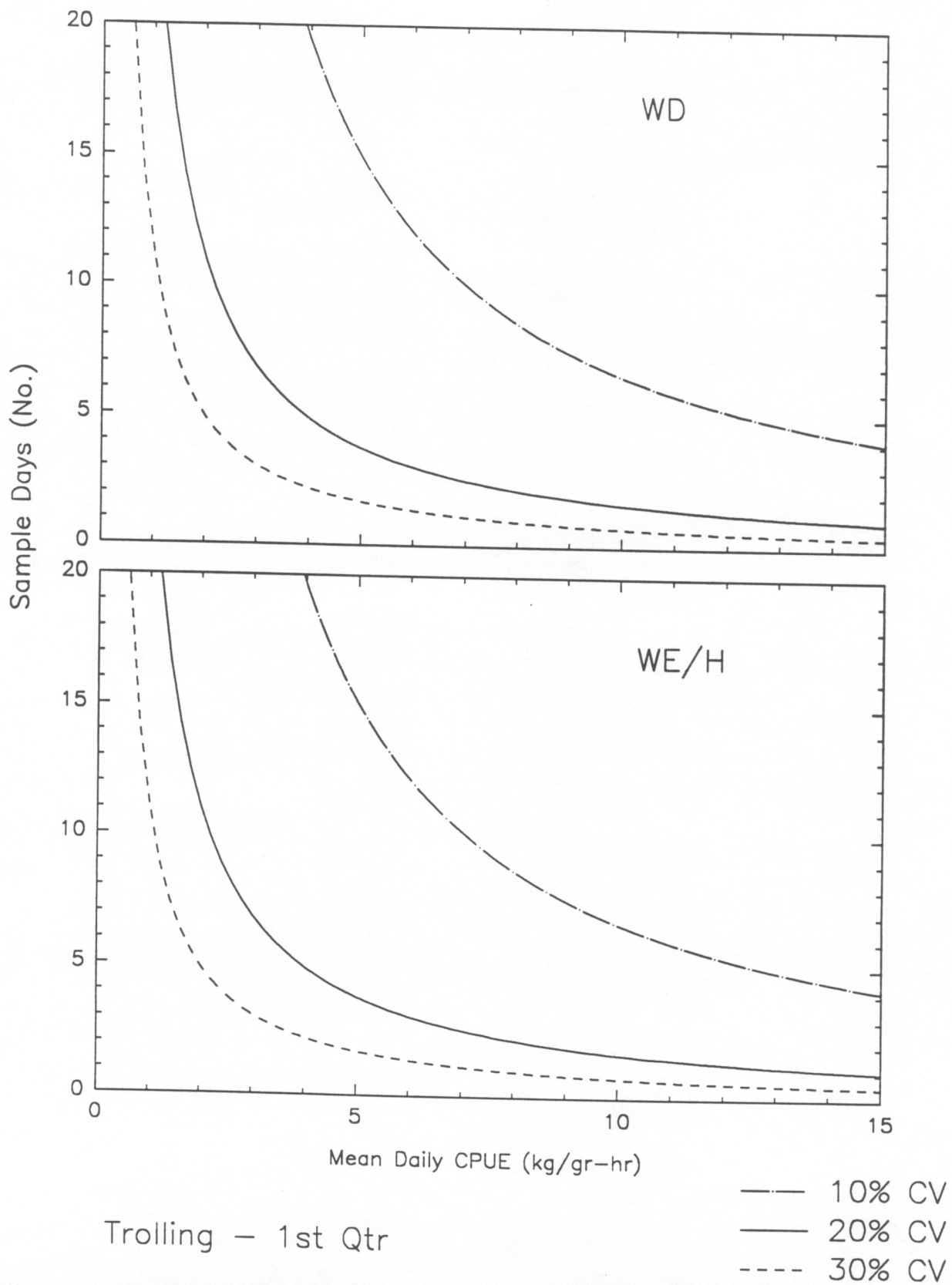


Figure 14.--Required sample size for estimating first quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/h.

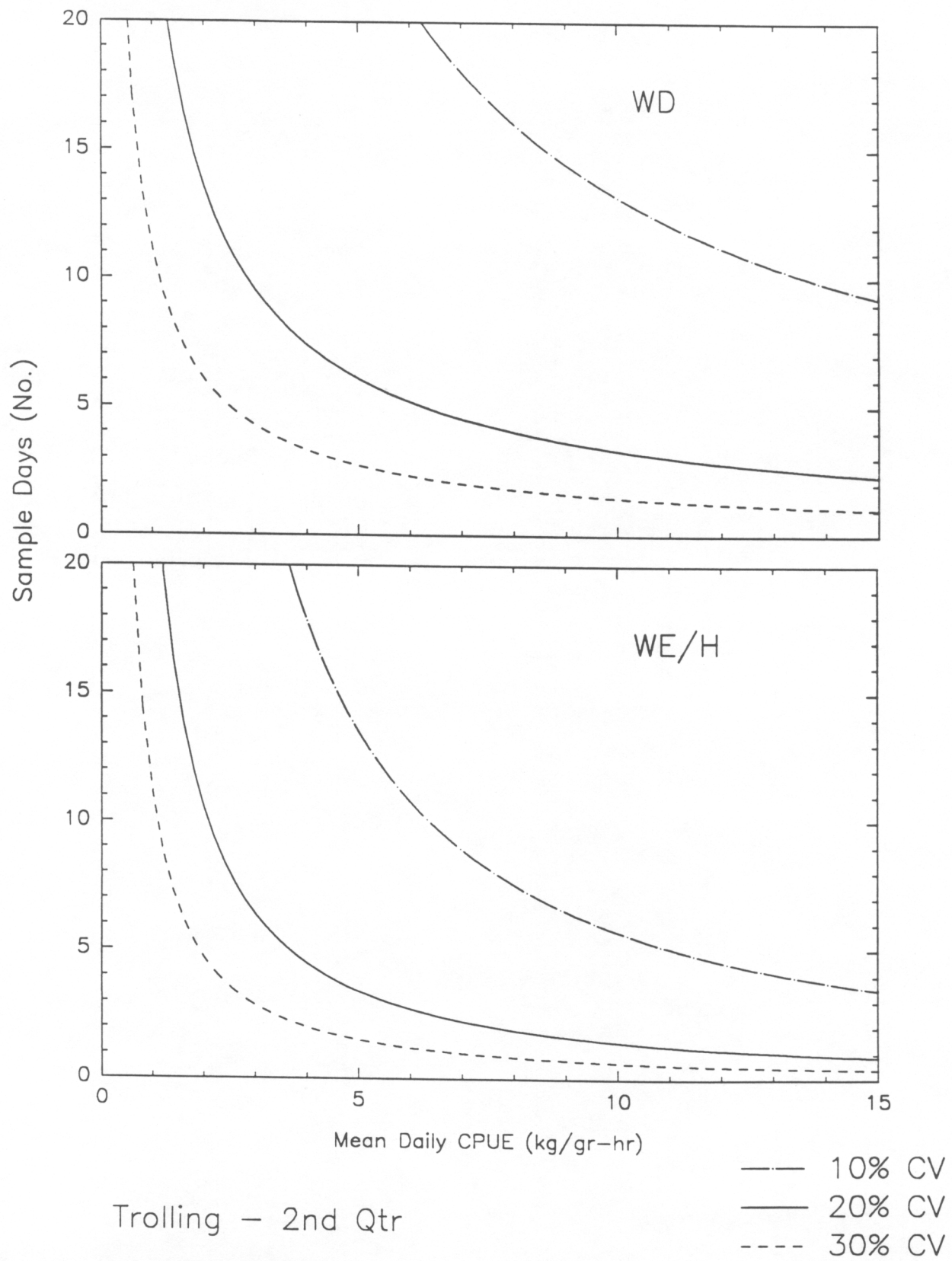


Figure 15.--Required sample size for estimating second quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H.

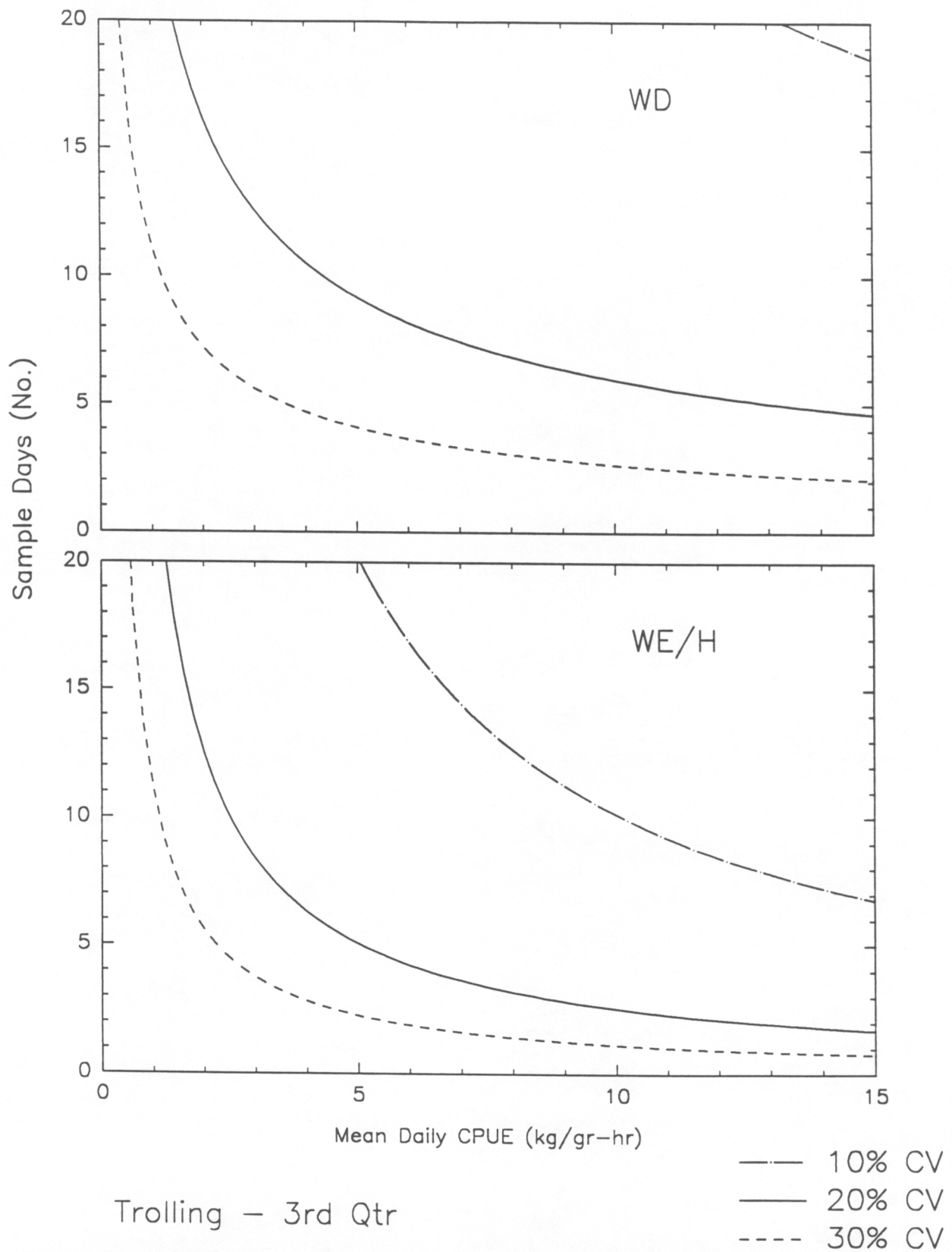


Figure 16.--Required sample size for estimating third quarter mean daily trolling CPUE at the 10, 20, and 30% CV levels for both WD and WE/H.

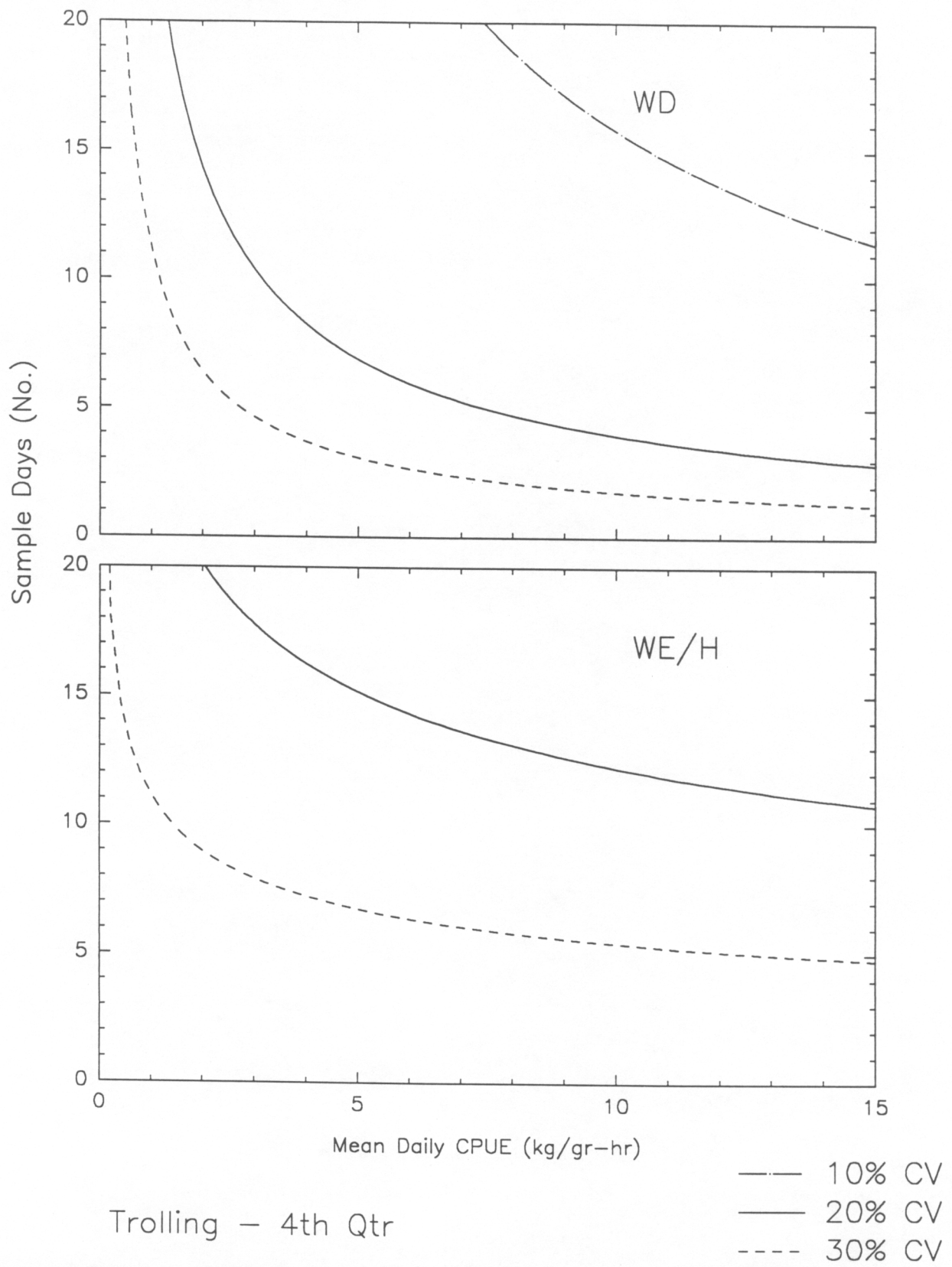


Figure 17.--Required sample size for estimating fourth quarter mean daily trolling CPUE at 10, 20, and 30% CV levels for both WD and WE/H.

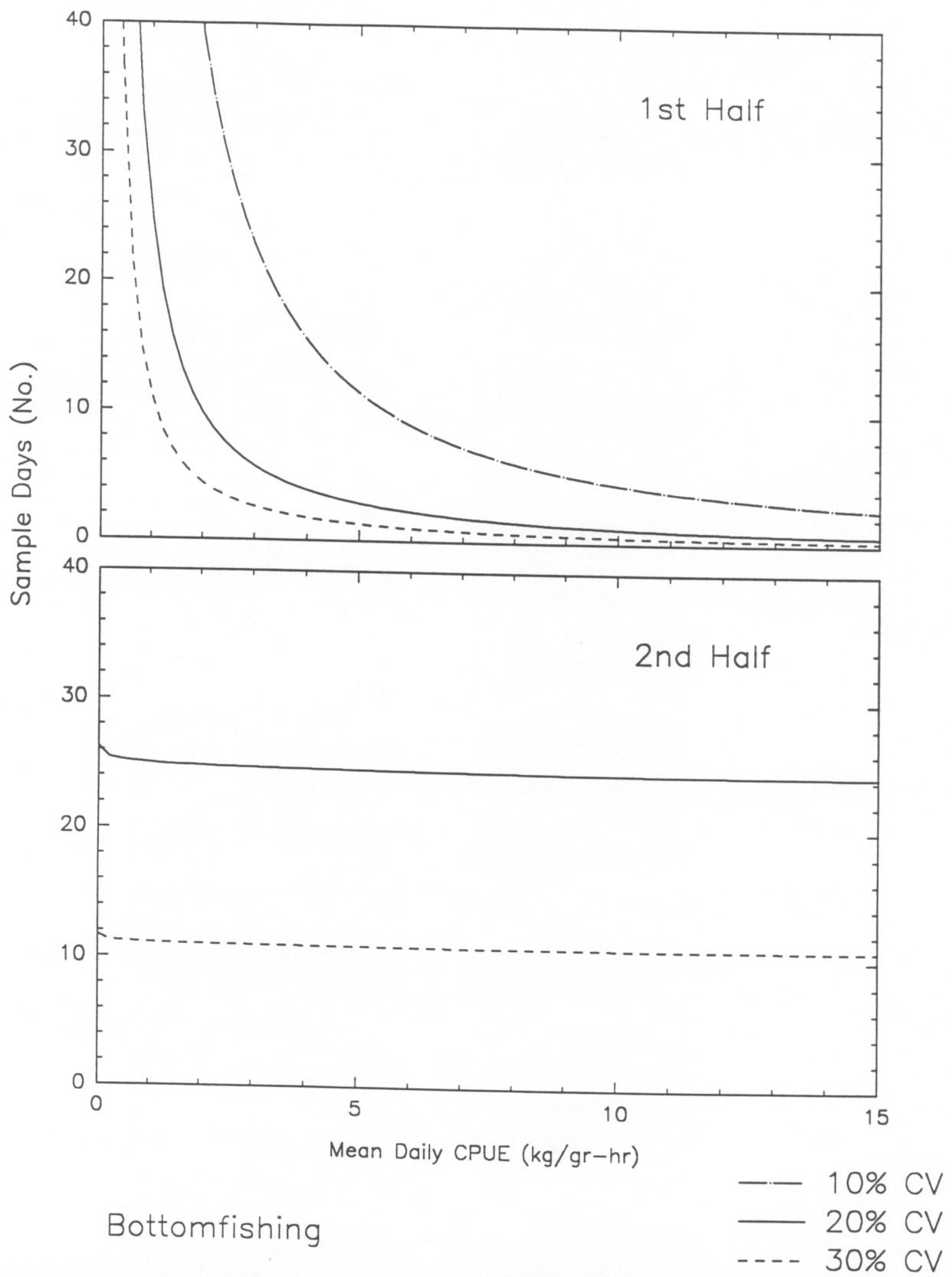


Figure 18.--Required sample size for estimating bottomfishing CPUE at the 10, 20, and 30% CV levels for both halves of the year.

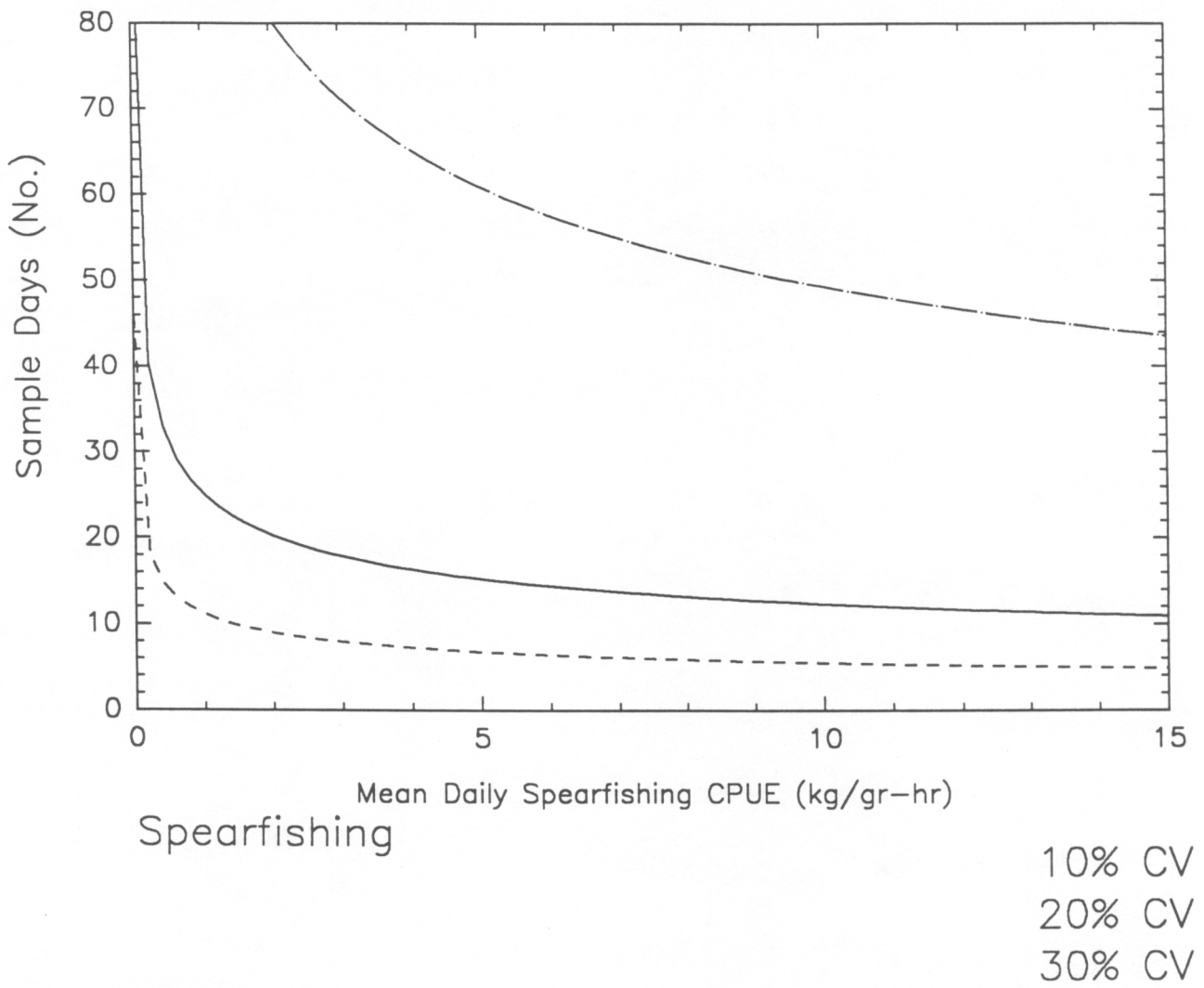


Figure 19.--Required sample size for estimating annual spearfishing CPUE at the 10, 20, and 30% CV levels.

Saipan Annual Landings
Commercial and Expanded Offshore Survey Data

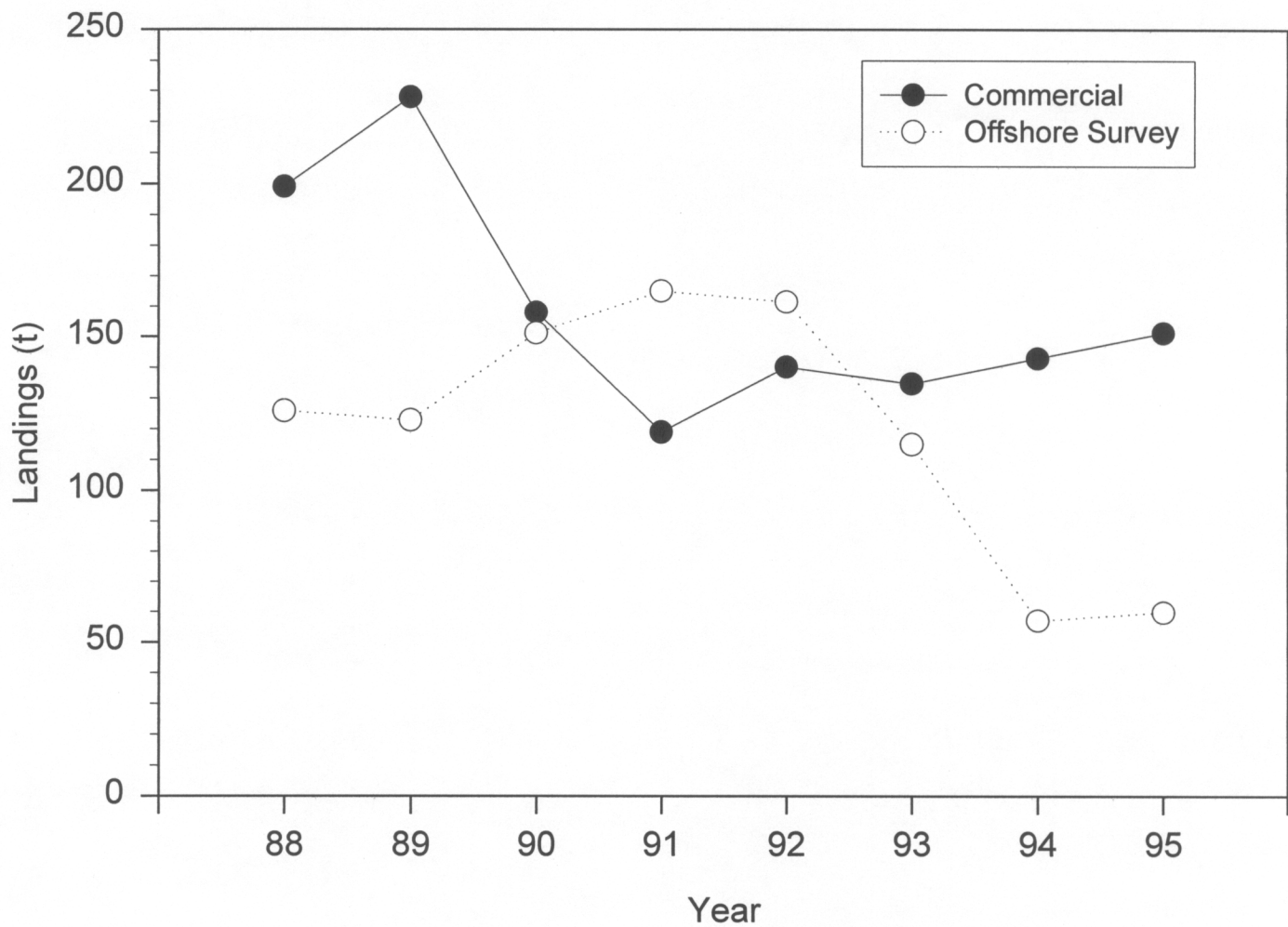


Figure 20.--Estimated annual landings on Saipan in the CNMI from commercial sales ticket receipts and offshore creel surveys from 1988-93.